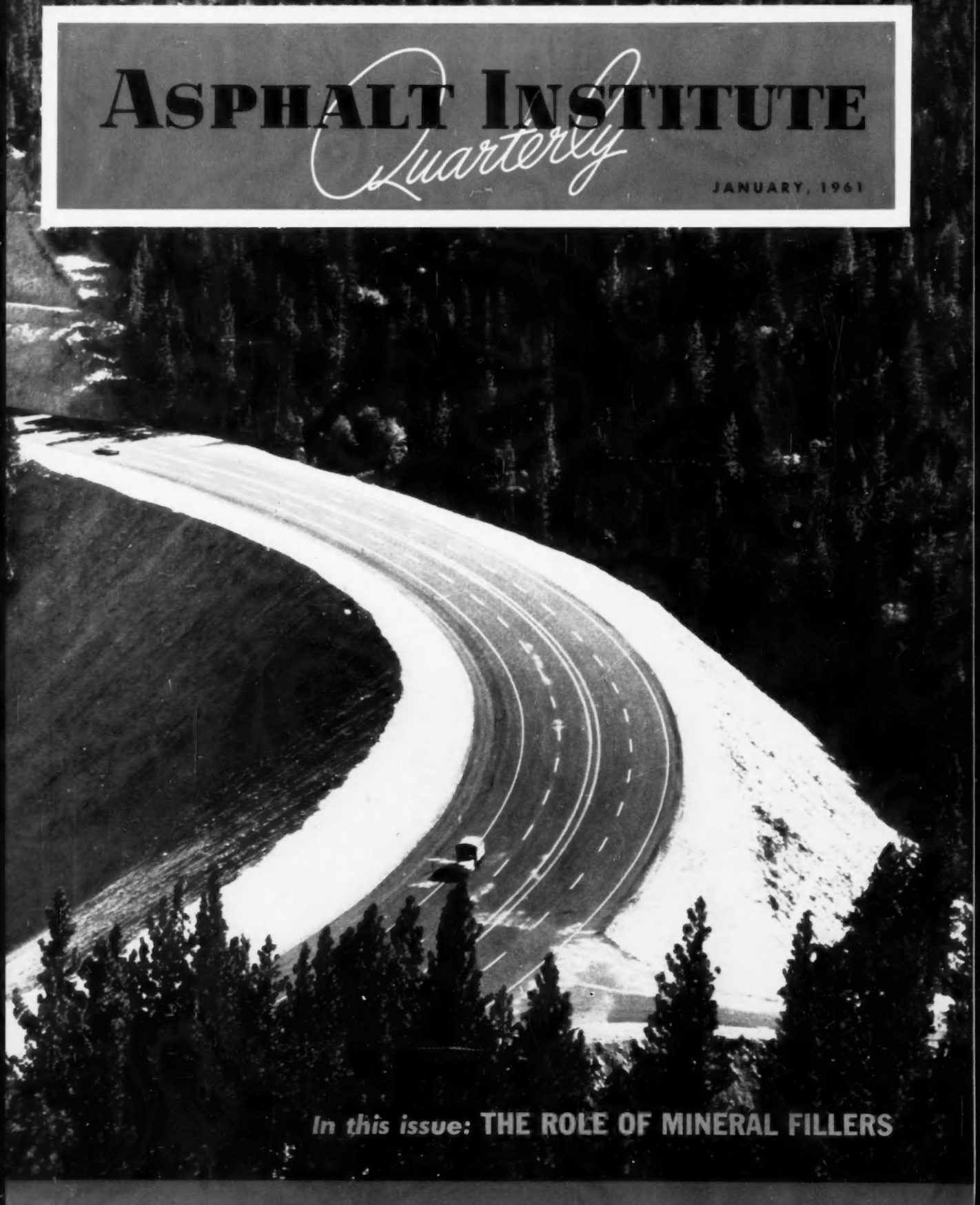
Asphalt Institute Quarterly

JANUARY, 1961



In this issue: **THE ROLE OF MINERAL FILLERS**

L. P. STREET
Chairman, Board of Directors

For 1961, Chairman of the Board of The Asphalt Institute is L. P. Street, vice president of the American Bitumuls and Asphalt Company with headquarters at Baltimore, Maryland. Mr. Street is a native of West Virginia and took his engineering degree at West Virginia University. He served with the West Virginia State Road Department and a brace of contractors before joining the field force of the American Bitumuls company a quarter of a century ago.

A Challenge and an Opportunity

By L. P. Street

As we turn the corner into a new year we find ourselves facing into a whole new decade—replete with challenges and responsibilities, but more than balanced with golden opportunities to garner success far surpassing anything of which our industry has dreamed in the past.

We are confident that with the new techniques which have been developed in utilizing properly compacted base aggregates and with the advances to come in adequately designed and properly compacted asphalt pavements, we not only have something to offer the road-builder, but in addition, have a responsibility to see that all engineers who are interested in the design of heavy-duty pavements are fully informed with respect to the economy, durability, and advantages of asphalt paving.

At this time, on the part of the manufacturers of asphalt, The Asphalt Institute, and bituminous paving contractors, there is a desire, far beyond that of any past period in our history, to improve the quality, durability, and life of asphalt pavements. This desire is supported by vast expenditures for research by the manufacturers of asphalt and by financial assistance, technical support, and cooperation that the petroleum companies are contributing to the Asphalt Institute. In all segments of the industry there is a true desire and resolve to supply the best in quality and service to customers using our products.

Advancing steadily on all technological fronts, we can confidently expect to win a host of new engineering friends for asphalt in 1961 and in the decade ahead.

EXECUTIVE COMMITTEE, 1961

Seated: E. F. Shannon, Continental Oil Company, Houston; Francis H. Brown, Mobil Oil Company, Kansas City, Mo.; L. Parke Street, Chairman, American Bitumuls & Asphalt Company, Baltimore; A. T. Van Pelt, Berry Asphalt Company, Magnolia, Ark.; Joseph W. McCracken, Byerlite Corporation, Cleveland. Standing: A. R. Curtis, Esso Standard, Division of Humble Oil Company, New York; Robert S. Ketcham, Anderson-Pritchard Oil Corporation, Oklahoma City; L. B. Fox, Treasurer, Mobil Oil Company, New York; Eugene M. Stone, Past Chairman, Empire Petroleum Company, Denver; Robert M. Clark, Wilshire Oil Company of California, Los Angeles; Robert C. Hawks, Mobil Oil Company, New York. Missing are S. J. Diegel, Sinclair Refining Company, Kansas City, Mo.; and George T. Goggin, Douglas Oil Company of California, Los Angeles.

ASPHALTOPICS

From Reader A. I. Watkinson of Yorkshire, England, comes a packet of literature flying the house flag of the Railway Conversion League—and with a query: "Are there any abandoned railroads in America now serving as motor roads?" It seems the RCL is all for shunting a lot of marginal railroads onto a permanent siding and using the abandoned right-of-way for sorely needed expressways. This is the League's answer to Britain's traffic crisis. We know Virginia is talking about buying a spur line of the Old Dominion Railroad just outside Washington, D. C., for this purpose. And did they ever decide to bring the Massachusetts Turnpike into Back Bay over the old Highland Branch of the B&A? We'll be happy to report back to Mr. Watkinson if our readers can be of any help in this project.

* * *

DATELINE NINETY SIX: Moisture, rising through the floor boards, can raise the dickens in a spinning mill. So the Greenwood Mills at its new plant in Ninety Six, South Carolina, placed a vapor barrier consisting of about 30,000 square yards of hot sand-asphalt in its spindle area before laying the flooring. Three inches of sand-asphalt were placed on four inches of stone base, screeded by hand, and left uncompacted. After a wood deck was tamped into the hot mix, a pine sub-floor was laid diagonally, followed by a silver paper laid diagonally to the sub-floor as a barrier for the treated sub-floor. On top of this, the finished maple floor was placed. And, finally, to satisfy your curiosity, we have it on the authority of a magnolia-voiced clerk in U. S. Senator Strom Thurmond's office that the town of Ninety Six got its name from the fact that an Indian maiden ran that distance to warn white settlers of an attack. When she arrived at the stockade, her pedometer read 96 miles, so one of the settlers exclaimed: "By gum, we'll name the town Ninety Six." Preposterous, isn't it?

* * *

NO PACKAGE DEAL—When they built South High School in Wichita, Kans., they didn't lump the asphalt parking lot project in with the general contract. Instead, they invited separate bids and saved more than $30,000 by soliciting the competitive bids of specialists in this paving field. Low bid for six inches of cement concrete was $4.35 per square yard and low bid for seven inches of asphalt concrete was $2.04. Other school boards please copy.

(Continued on page 11)

NEW INSTITUTE PUBLICATIONS

Asphalt Paving Manual—This is a companion book to the *Asphalt Plant Manual*, prepared in the same format and style. Two years in the preparation, this manual is a step-by-step guide for the paving engineer and contractor placing plant-mix asphalt pavement. Manual Series No. 8.

How to Pave Barnyards with Asphalt—A reprint of an excellent article by this title which appeared originally in Hoard's Dairyman. By D. W. Bates, Extension Agricultural Engineer at the University of Minnesota. 12pp. with illustrations. Information Series No. 113.

Main Street U.S.A. Is Asphalt All the Way—A handsome 16pp. brochure incorporating several articles on city street paving and maintenance which have appeared in the *Asphalt Institute Quarterly*. For municipal administrators, home-owners and taxpayers. Information Series No. 114.

ASPHALT INSTITUTE *Quarterly*

Vol. 13, No. 1 **January, 1961**

Glynn Harvey
Editor

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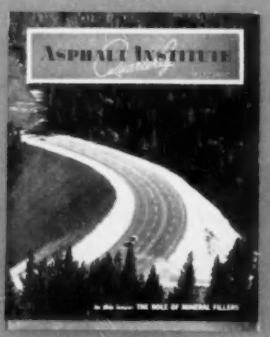


Swooping down the slopes of the Sierra Nevada range from Lake Tahoe, the Clear Creek Highway (U.S. 50) is a magnificent piece of road engineering. Cover photo shows a three-bench cut carved out of the granite hillside. Here the roadbed perches bravely on the crest of 152 feet of fill blasted from the rock wall. This is another excellent asphalt-paved highway built in recent years by the State of Nevada.

—Nevada State Hwy. Dept. Photo

The Asphalt Institute Quarterly is published by The Asphalt Institute, an international nonprofit association sponsored by members of the petroleum asphalt industry to serve both users and producers of asphaltic materials through programs of engineering, research and education.

The member companies of the Institute, who have made possible the publication of this magazine, are listed on page 15.

Articles may be reprinted with credit lines. Correspondence should be addressed to the Asphalt Institute Quarterly, Asphalt Institute Building, University of Maryland, College Park, Maryland.

THE METROPOLITAN

PIERCE County, Washington, located on the Western slopes of the Cascades Mountains from their summit to Puget Sound, is in a period of transition, changing from a rural county to a standard metropolitan area. The population in the unincorporated areas has risen in two decades from 58,655 to 147,338—a growth of 251%.

This population growth, like that of other metropolitan centers, occurred outside, but adjacent to the incorporated cities. The main city in this area is Tacoma. Virtually overnight, sleeping farm communities have become sprawling urban suburbs with new developments, including shopping centers, schools, and large scale housing activities.

Pierce County embraces a land area of 1701 square miles with topography ranging from level land and rolling hills near the shores of Puget Sound to mountainous areas that include 14,408-foot Mount Rainier. The average rainfall is 37 inches, and the temperature ranges from 20° to 90° F. Soil conditions range from alluvial clays and silt to good sand and gravel. These soil variants result in drainage conditions that have become critical in the urban areas.

TIMBER ECONOMY

The economy of Pierce County is based principally on timber products, Fort Lewis, the Northwest's largest military installation, and McChord Air Force Base. These factors must be considered in any road construction program. Logging trucks, consisting primarily of trucks and semi-trailers carrying a gross weight of 74,800 pounds distributed on five axles,

Keith F. "Casey" Jones is a native of the State of Washington, where he has lived and worked most of his life. He received his engineering education at the University of Washington, and is a licensed civil engineer in the State of Washington.

On completion of his engineering education, Mr. Jones began work with the Washington Department of Highways, later becoming county engineer for Jefferson County, situated on the rugged Olympia Peninsula. During this time he developed a county road system, unified in operation and county-wide. These principles have since been accepted by many other counties in modernizing their county road program. Mr. Jones left Jefferson County three years ago to become county engineer for Pierce County, a growing metropolitan county.

Beyond the City Limits the County Engineer is Battling the Urban Sprawl

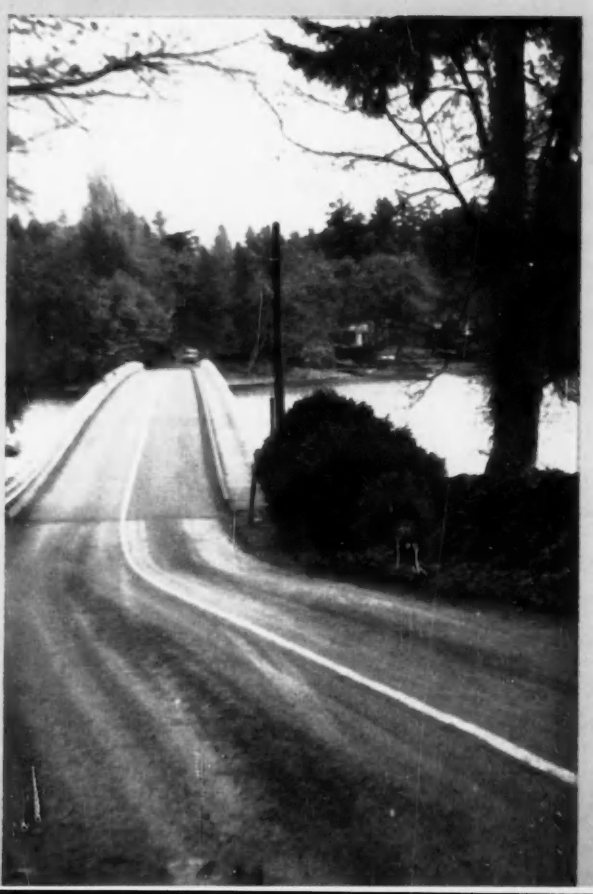
MUDDLE

By Keith F. Jones
County Engineer, Pierce Co., Washington

depend heavily on the use of county roads to bring 70% of the raw materials to the mills situated in the Tacoma and Pierce County areas. Military personnel, consisting of approximately 35,000 uniformed and 2,500 civilian force working at Fort Lewis and McChord Air Force Base, add materially to the traffic considerations.

In addition, the army moves heavy equipment over county roads, causing problems in the reinforcement of the road and its structures. Some of these loads moved by the army weigh in excess of 150,000 pounds, causing undue stress on both road surfaces and road structures. This heavy loading requires higher class road construction.

To cope with the problems of operation and administration, the Pierce County Road Department is divided into two divisions, Engineering and Maintenance. The Engineering Division numbering 35 persons, is charged with the duties of all phases of engineering work connected with the Department. To accomplish its mission, the Division is departmentalized into Planning, Traffic, Right of Way, Construction and Contracts, and Accounting. The Construction and Contracts Department handles all contracts and does engineering work on all day labor jobs. The Accounting Department handles all payrolls, and both fiscal and cost accounting. It is possible that, as growth in the country continues and demands for more service arise (such as flood control, storm sewers, and roadway lighting) new departments will be needed. We try to keep down the number of departments since we have found that over-departmentalizing tends to raise overhead costs.



Pierce County has many mountain roads like this one, expensive to build and costly to maintain

WORKING MAINTENANCE FORCE

The Maintenance Division is charged with the responsibility of protecting the county's investment in the road system by keeping this system in a usable condition. In this area, maintenance requirements vary from season to season and from year to year. To accommodate these conditions in maintenance, it is more economical to keep a division large enough to meet the demands of the peak maintenance periods. And, to keep this force, it is necessary to fill in during slack maintenance periods with small construction and betterment jobs. Most of these jobs are under $10,000 each and are confined to the type of work in which overhead and labor costs would be high to a contractor. Thus, a skilled maintenance force is kept with very little expensive labor turnover.

To gain the advantage of special skills and training of members of the division, crews have been developed for specialized jobs, such as sign crews, shop crews, patching crews, oiling crews as well as general maintenance personnel.

The annual budget for all road purposes during 1960 was $2,634,000. Of this total, $150,000 was received in Federal Aid, and the remainder derived almost equally between local taxes and gasoline taxes. This compares to a 1950 budget of $1,208,000. Although the increased budget reflects a gain of about 117% over the past ten years, population increase and inflation have brought about much greater need than the increase in the budget indicates. The need for new road construction funds have been so great in the past few years that we spent only enough money on maintenance of existing roads to assure the upkeep of facilities to the extent that the original investments will not be lost or the public inconvenienced. As much money as can possibly be spent on new construction is earmarked for that purpose. Presently, about 50% of the funds go for new construction and the remainder for maintenance.

20-YEAR ROAD PLAN

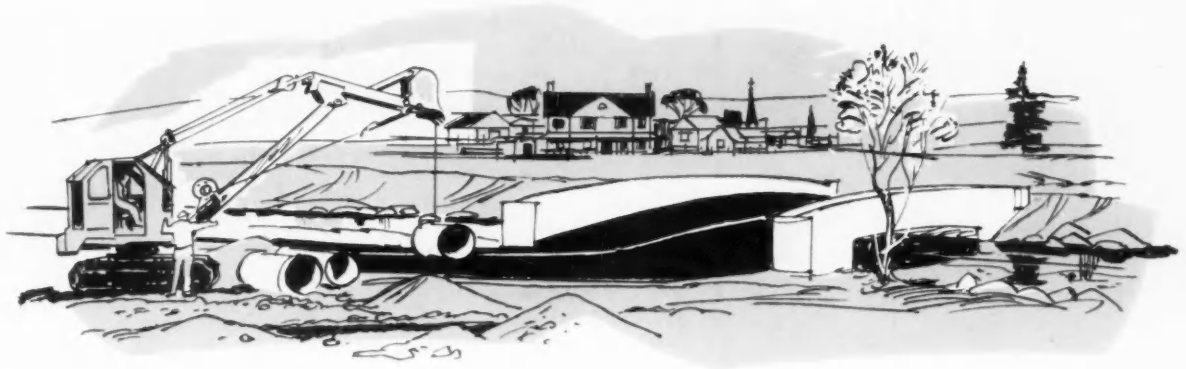
To make certain that the roads being built and improved would fit into an over-all development of the county, it was necessary to develop a twenty-year arterial road plan and highway needs study which showed the location and cost estimate of all major and minor arterial roads and streets needed in Pierce County during the next 20 years. This arterial road and needs study was based on population growth, building trends, zoning, traffic desires, tolerable standards of roadway to carry anticipated volumes of traffic, and all other known factors that might affect road development in the next 20 years. The arterial road plan and need study pointed out that a large deficiency in the expected income and the cost of developing necessary roads and streets exists—emphasizing the need for careful programming of existing road funds.

Standard county paving sections on rural roads require 22 to 24 feet width for two-lane roads and 48 feet widths, with adequate shoulders, for four-lane roads. The main intersections, where the volume of traffic is high, are channelized and signalized. The high cost of channelization and signalization, and the increased demand for this type of installation, is a considerable drain on the construction budget. Though this smooths the flow of traffic, it provides few miles of improved roads per year.

PIERCE COUNTY ROAD MILEAGE
By Surface Type

Graded and Drained	2.26
Gravel	444.02
Bituminous Surface Treatment	787.99
Asphalt Concrete	92.03
Portland Cement Concrete	74.98
Total Miles	1401.28

Curving streets in Pierce County subdivisions reduce throug



CHEAP AGGREGATE SOURCE

Sand and gravel deposits, present in most areas of Pierce County, are sources of cheap aggregates for asphalt concrete and other types of bituminous surfacing. This has made it economical for Pierce County to use some type of bituminous mixture to surface all county roads that require a hard pavement. A light bituminous surface treatment is used exclusively to surface roads and streets with low (under 5,000 vehicles) traffic volumes. Plant mix asphalt concrete is used to surface roads having high traffic volume. And those having considerable stop-and-go traffic. The light bituminous surface treatment consists of two applications of 0.3 gallon per square yard of MC3, covered with 150 cubic yards per mile of $\frac{5}{8}$"-0 cover stone, with a subsequent seal coat when necessary—generally a seal is required every five to seven years, depending on conditions.

On some roads, a high volume can be expected in the future. When this occurs, it is planned to cover the light bituminous surface with sufficient plant-mixed asphalt concrete to raise the standard of the surface so that it will accommodate the higher volumes. Some roads are adjacent to and serve rapidly expanding areas. Frequently few utilities such as water, sewer, surface drainage and gas exist and we know that, in the future, these utilities will have to be installed. By postponing the application of a permanent surface and using a light bituminous surface treatment, we hope to see these utilities installed before it is necessary to place the asphalt concrete.

On roads having a daily volume of 5,000 to 12,000 vehicles and where utilities have not been constructed, two inches of plant-mixed asphalt concrete have been used with the thought that after the utilities have been installed, additional asphalt will be placed to make up a permanent surface. Presently, roads carrying as high as 12,000 vehicles daily, with two inches of asphalt concrete, applied over a good base, are showing no distress after three years service.

DRAINAGE COSTS HEAVY

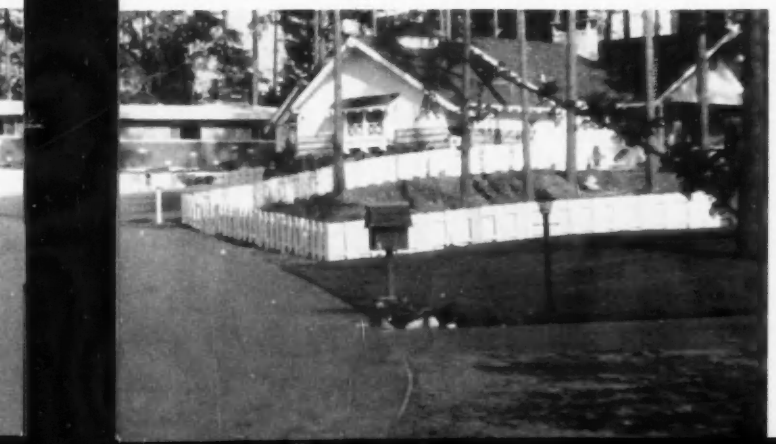
One of the largest urban road costs is drainage. In the past, it has been the practice for land developers and the county to run surplus surface water into vacant lots or other dry water channels. When this channel or lot became occupied, the water would be directed to the next unoccupied lot or dry water channel. This brought on such problems that immediate relief became necessary. By using the arterial road plan, recently completed for Pierce County, a subsequent drainage plan that coincides with the arterial plan, is presently being worked out. This will enable surface water to be taken to an ultimate destination such as Puget Sound on other natural water courses.

The development of the arterial road and street plan makes it possible to require subdividers to dedicate adequate right-of-way for proposed major arterial streets, thus saving considerably on right-of-way costs. It also assures that the subdivision will be developed in an orderly manner rather than in a hodgepodge of narrow streets and traffic bottlenecks. This advance planning is doubly important because most of the subdivisions in this area are being laid out with short cul-de-sac streets and with streets following natural contours. This system, though hard to serve with roads, provides better living conditions and contributes to the safety of the residents by assuring low traffic volume and low speeds on residential streets.

Pierce County's present annual budget of $2,600,000 and the expected increase to $5,000,000 by 1975, leaves the county far short of being able to serve traffic demands as shown in their arterial road and need study. It would seem by a comparison of the expected revenue with the needs, the problem would be insurmountable.

Pierce County does not believe this is so. Supplementing this revenue by requiring the land developers to build all the access streets and providing right-of-way for the arterials to serve these access streets, and by using the county's authority of rural improvement districts, they are confident that they will still have traffic moving smoothly in 1975.

raffic and increase residential property values appreciably



THERE'S no such thing as pavement failure. There is only human failure, resulting inevitably in pavement distress.

This failure may result from poor design or materials, or over-loading, or sloppy construction practice. But the most common failure of all is simple neglect of maintenance. And most frequently abused in this respect is the light-duty asphalt pavement—the type usually found at the budget-cramped county and township level.

Pavement distress, also, may take several forms and may range in severity from chronic to acute. Of course, a thinly-built asphalt pavement is doomed from birth to a form of chronic anemia. It is never very robust although it may display astonishing vitality, particularly with timely and adequate maintenance.

WATER GREATEST FOE

The greatest single enemy of all pavements is water. Of the several pavement troubles catalogued on the facing page, the principal cause in most instances is inadequate drainage. It is axiomatic that a pavement is only as sound as its base, and a saturated base is virtually no base at all. It's almost impossible for a highway engineer to be accused of fanaticism on the subject of drainage. Here is the rare instance where obsession is merely an extreme form of prudence.

Patching is engineering surgery, prescribed when the disease is deep-rooted, organic, and beyond simple surface treatment. In patching a distressed pavement, the engineer should first remove the surface and base materials to the full depth of failure, cutting out an area of from six inches to a full foot beyond the apparent perimeter of surface damage. Otherwise, cracking may resume around the perimeter of the distressed area.

The faces of the excavation should be straight and approximately vertical, and the hole should be shaped so as to offer a square shoulder in the direction of traffic. Additional granular or asphaltic base materials should be tamped into the cavity, if necessary. Then the pre-mixed material—hot or cold—should be placed and compacted in one or more lifts. It should be raked toward the cavity edges to give the proper "feathering" effect, and the patch should be compacted to a height of about a quarter of an inch above the adjacent surfaces to allow further compaction under traffic.

(On low type asphalt roads with little or no foundation, squaring out the hole may not be warranted. However, the loose materials should be removed and the edges tacked.)

PENETRATION PATCH POPULAR

Penetration-type patching is quite popular in some areas. Essentially, the work is similar to new bituminous penetration macadam pavement. The mineral aggregate is uniformly spread and compacted, after which an asphalt binder is spread by kettle or small distributor. If done properly (taking care to avoid a rich or lean patch) this method produces an excellent low-cost patch with a minimum of equipment.

Regardless of the type of distress, or its cause, pavement maintenance should be done promptly. The moral of the stitch-in-time should be the daily working philosophy of the highway engineer. In most instances, these local by-ways and secondary roads are products of the evolutionary process: they have grown to pavement status through a series of surface treatments. But, in many instances, a sound base is lacking and, consequently, repairs must always be regarded as alleviating the distress without curing the condition.

Again reverting to the medical metaphor, the pavement is a patient under treatment for a chronic disease. Timely maintenance is the drug which checks the deterioration, but if we withhold the drug the patient must inevitably suffer a relapse—sometimes fatal.

THE PAVEMENT CLINIC

An Out-Patient Approach to the Ills Of the Light-Duty Asphalt Pavement

The Fever Chart

TYPE OF DISTRESS	PROBABLE CAUSE	TREATMENT
Edge Failure	Insufficient thickness of mat, excessive loads, lack of shoulder support, base saturation—usually due to high shoulders, trapping run-off.	Check drainage and clean ditches. Check shoulder for permeability and, if shoulder is high, blade it down to surface grade and compact. Fill cracks and seal coat outer edge.
Weathered or Dry Surface	Insufficient asphalt, or overheating of asphalt (if a plant mix), age of pavement, or adsorptive aggregates.	Fog seal of dilute, slow-setting asphalt emulsion (SS-1 or SS-1h) at rate of approximately .10 gals. psy; if they are pitted areas needing filling, use of a slurry seal or conventional seal coat is recommended.
Pot Holes	Any of the several types of distress cited here will lead to pot-holing; also, water infiltration, unstable base, insufficient asphalt to maintain a bond, or open or segregated mix.	Square up hole, making sides almost vertical; replace lost base material, if necessary; spray cavity lightly with diluted asphalt, fill with premixed material to compacted height that will allow for additional traffic compaction; finally, seal with 0.1 to 0.25 gals. and 10 to 25 lbs. of cover psy. Penetration patch also used frequently.
Alligator Cracking	Base saturation, lack of base support or insufficient thickness of mat.	Check and correct drainage faults; apply thin coat of liquid asphalt with cover of mineral aggregates at rates given above. (If necessary, repeat treatment to furnish needed reinforcement.) Sometimes patching is indicated.
Bleeding and Instability	An excess of asphalt, changing its character from binder to lubricant, or presence in mat of large amount of silt or clay, with rounded gravel, lacking interlock. Often, moisture, accumulating beneath surface, destroys the bond and traffic pushes the pavement to form waves or ridges.	Scarify, re-mix and re-lay, adding sand if there is an excess of asphalt; where the cause is weak base and/or poor drainage, underlying fault must first be corrected. Sometimes shoving and pushing may be corrected by honing or blading off ridges, patching, and seal coating.
Ravelling	A lean or over-heated mix.	Apply fog seal, regular seal with cover mineral, or slurry seal as judgment dictates.
Base Saturation	Standing water in side drains, leaking ditches or culverts, or other condition which traps moisture beneath the surface. Too high a percentage of fines, or presence of plastic fines in the base.	Clean ditches and install new or additional drainage as indicated.
Longitudinal and Transverse Cracking	Contraction, or subgrade movement.	Crack-filling and sealing.
Distortion and Depression	Inadequate compaction of subgrade or base.	Spot leveling and skin patching.

Maine "Makes Do" . . .

In Sparsely Populated Pine Tree State, Husbanding of Secondary Road Resources is a Test of Yankee Ingenuity

ALTHOUGH one of the original thirteen, Maine is one of the few remaining states where a man can get swallowed up without a trace in a trackless wilderness.

In other words, population growth in this large state has been fairly slow, tending to concentrate in the manufacturing cities which cling to Maine's rushing rivers and rock-ribbed coast. The backbone of the state's 11,000-mile highway system is the 7,500 miles of secondary roads that straggle away into the brush and timber.

Thus, in a country subjected to severe winters and deep frost penetration, it takes a lot of Yankee ingenuity and stubborn determination to maintain these low traffic volume roads—and to improve them steadily as changing conditions require.

The Maine State Highway Commission cannot afford to be profligate in its handling of roads resources. Wherever possible, the existing roadbed is preserved and incorporated into the new structure when up-grading of a road is called for. The old roadway is brought to true level with a variable thickness of gravel base, providing stability and improving the gradient. Generally, the base course is extended over the old shoulder sections to provide additional width of roadway and shoulder, called for in the revised geometric design standards.

After leveling and widening, the new gravel base is sealed

BEFORE: Typical Maine secondary road before widening and leveling. Random cracking shows need for thicker structure

AFTER: Wider roadway and new shoulder with added thickness of pavement provides sturdy modern road for modern traffic

(with an MC grade asphalt) and allowed to stand for at least one winter. There are three principal reasons for using this stage construction technique:

1. It permits time for settlement and additional compaction under traffic.
2. It offers an opportunity to detect weak areas in the old roadway foundation which is subjected to frost penetration ranging to a depth of six feet.
3. Economically, it makes it possible to include several projects in a single paving operation, requiring only one move and set-up of both the aggregate processing and paving equipment.

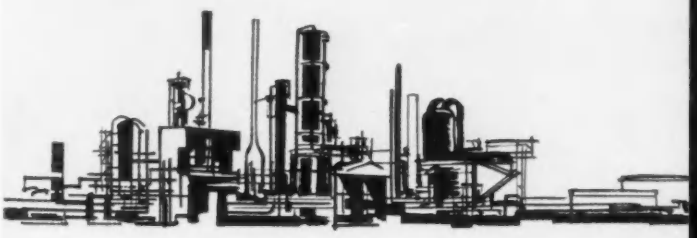
There are four principal types of surfacing used in Maine's secondary road improvement program: asphalt surface treatment, a mixed-in-place asphalt surface, a travel mix, and a hot mixed asphalt concrete mat.

TRAVEL-MIX USED

The travel-mix type of construction has been used extensively in Maine, and with considerable success. A typical up-grading project of this kind consists of the following steps:

First, drainage features are improved. Ditches are cleaned and reshaped. Where needed, new ditches are cut and new drains are installed to carry off surface and sub-surface water. The new gravel base is placed as described above and, after the sealed base has been exposed to traffic compaction and frost adjustment for the required period, two to three inches of travel-mixed asphalt surface course is placed.

Usually, the cost of this typical project is less than half the cost of a full contract construction project of the same scope of design thickness. The work generally is performed by the regular maintenance crews and the Maine State Highway Commission regards the cost as comparable with a few years of regular maintenance costs on the old roadway. Considered in this light, Maine is squeezing a lot of miles of modern secondary highways out of a tight budget.



ASPHALTOPICS

(Continued from Page 3)

Of special interest to members of the petroleum asphalt family was the action taken recently by the American Association of State Highway Officials. The AASHO Specification M-20 for Asphalt Cement has been revised in its section on Manufacture to read: "Petroleum asphalt shall be prepared by the refining of crude petroleum by suitable methods." The old wording read: ". . . by the distillation of asphaltic petroleum." The AASHO also has adopted five penetration grades of asphalt for its specifications (40-50, 60-70, 85-100, 120-150 and 200-300). These are the five grades adopted three years ago by The Asphalt Institute and proposed for acceptance by the states.

* * *

Here at College Park, Md., asphalt paves the way to the lofty academic life. Braced for the anticipated rush of "war babies," the University of Maryland this year installed sixty-four trailer dormitories to house first-year men students (see picture). Paving the walks and play areas kept hot-mix tonnage pouring onto the handsome campus which, in the last three years, has added thousands of square yards of drives and parking areas to accommodate the 12,000 registered motor vehicles at the university.

* * *

WHAT'S NEW—An Infra-Red Joint Heater, developed by Pavement Salvage Inc. of Pittsburgh, appears to be a solution to an old problem: how to achieve a perfect joint bond between new hot material and an existing pavement. This propane gas heater attachment can be welded to the side of a paver in a matter of minutes, and quickly brings a cold pavement joint back to a working range of 200-275°F for annealing to the new material.

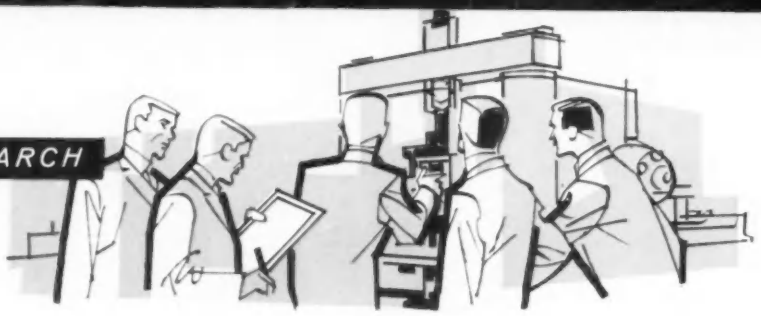
* * *

The principle of "spending to save" has found an aggressive champion in Michigan State Highway Commissioner John Mackie who has directed that the shoulders on all new expressways (and several now in service) will be paved with asphalt concrete. In the past, Michigan has been satisfied to give its shoulders a double chip seal. The Commissioner points out that the higher initial cost will be amortized over the life of the pavement by lower maintenance.

* * *

Nine of every ten miles of paved roads and streets in the United States are surfaced with petroleum asphalt paving.

RESEARCH



The Role of

The problems of the asphalt technologist today are complicated by radically changing conditions. It is readily apparent that our pavements are being subjected to wheel loads of constantly increasing severity. And we can safely assume that this trend will continue. It's not uncommon today for a highway to carry upwards of 50,000 vehicles per day, many of them heavy trucks. On our military airfields, the situation is even more drastic; pavement loading and tire pressures have increased in proportions undreamed of a quarter of a century ago. . . .

To serve satisfactorily under these increasingly severe conditions, it is clear that the asphalt industry and the engineers charged with the design and construction of pavement structures must search continually for better and more exacting procedures in pavement design, for improvement in construction equipment and practices, and also for better understanding and, therefore, more intelligent use, of old and new construction materials.

This discussion will deal with a fractional element of the asphalt paving mixture; that fraction commonly known as "mineral filler." Although it represents only a small part of the mix, this fraction is of critical importance in the performance of the finished pavement.

The use of mineral dust in asphalt paving mixtures, as well as in a variety of specialty applications of asphalt, long has been common practice. Natural asphalts, used by older civilizations and still used extensively in some European countries, usually contain fairly large quantities of mineral dust. On the other hand, petroleum asphalts, used almost exclusively in this country and the U. S. are products of the crude refining process and are free from such mineral matter. Thus, the engineer has widest latitude in selecting the type and quantity of mineral dust best suited for his purpose. His problems relate to the proper understanding of the functions to be served by the mineral dust and to making an appropriate selection of materials to achieve these functions.

Some engineers consider the principal function to be the filling of the void spaces between the coarser aggregate fractions of the mix. In effect, this school of thought suggests that mineral dust can be used to replace a certain amount of asphalt in the mix.

Others approach the subject from a surface area concept, concluding that the large surface area of mineral dust will result in an increased demand for asphalt since there is more available surface requiring asphalt coating. It can be readily seen that these two viewpoints are in direct conflict, and it appears that neither is entirely valid. The truth would appear to lie somewhere between these two poles of thought and, depending on the characteristics of the mineral dust in question, must lean towards one or the other. . . .

—V. P. Puzinauskas, Assistant Engineer of Research, The Asphalt Institute, before Canadian Technical Asphalt Association, 1958

AN asphalt paving mixture consists of these ingredients: coarse and fine aggregates, mineral filler (normally present in the mix or supplemented by design), and asphalt cement. When all these ingredients are suspended in fine balance, the theoretical end result is an ideal pavement.

(We are assuming, of course, that certain conditions are met—such as adequate thickness design for the anticipated loads, careful preparation and placement of the mix, full compaction and proper drainage of the pavement structure, etc. When any or all of these conditions are overlooked, proper mix design is an exercise in futility.)

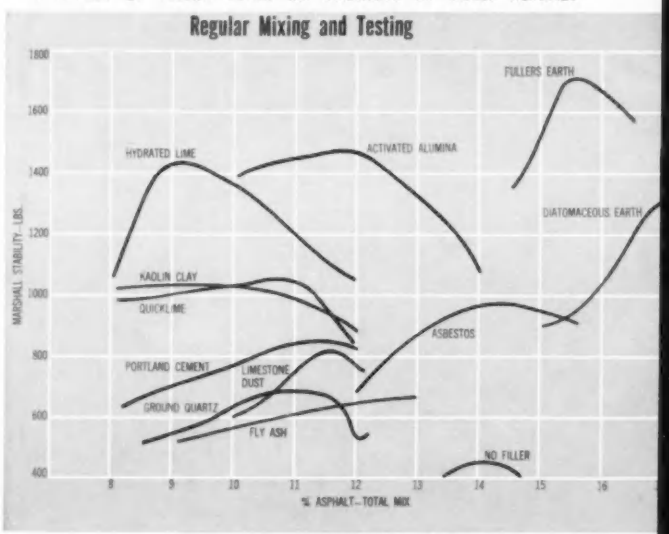
The role of the coarse aggregate fraction is fairly well understood by the paving technologists. This is true also of the fine aggregate fraction. Inevitably, the curiosity of the investigator has focused on the mineral filler.

What function does this fraction of the paving mixture serve? How do the various types of filler react with the asphalt cement? By altering the mineral filler content of the mix, how do we upset the fine balance of ingredients? Questions generated more questions, faster than tentative answers could be formulated.

PROJECT BEGAN IN 1957

The Asphalt Institute, already embarked on a laboratory research program in this area as far back as 1957, expanded its project. Studies started with diatomaceous earth, kaolin clay, limestone dust and portland cement were widened to include ground quartz sand, hydrated lime, Fuller's earth and short asbestos fiber. Later, other fillers were added.

1. EFFECT OF FILLER TYPES ON STABILITY OF SHEET ASPHALT



MINERAL FILLERS

in an Asphalt Mix

The problem that introduced a new note of urgency was: How to construct a pavement which will resist densification under very heavy wheel loads and high tire contact pressures like those encountered on military airfield pavements.

It is axiomatic in pavement design that greater resistance to densification can be achieved by reducing the asphalt content. But you pay for this gain with a corresponding loss in pavement durability. A dry brittle pavement won't last. On the other hand, a mix over-rich in asphalt content will offer greater resistance to fatigue, but there is a matching loss in stability. Bleeding and flushing of the asphalt occurs, along with displacement, under heavy wheel loads.

From experience, we know the most successful and durable pavement is the one that contains the greatest possible amount of asphalt, without sacrificing stability. The critical importance of mineral filler in arriving at these new, maximum stability pavements was suggested by the success of mastic-type pavements commonly used in Europe. Further evidence was offered by a very limited field investigation conducted by the Corps of Engineers, U.S.A., in which mixtures containing a high percentage of limestone dust performed especially well under severe loading conditions.

Laboratory investigations at The Asphalt Institute have been conducted in two areas—combinations of asphalt cement and the several fillers, and mixtures of filler-asphalt combinations and aggregates. All the fillers were used in sheet asphalt mixtures and many were used in dense-graded mixes.

These investigations by the laboratory team began accumulating data which, at times, appeared to be contradictory, frequently confusing. For example, early in the game it was discovered that the asphalt-filler mixes of higher viscosity usually showed higher softening points. Yet, sometimes this was reversed. The viscosity of asphalt-asbestos fiber mixtures at 77° F is lower than that of an asphalt combined with Fuller's earth or diatomaceous earth. But the softening point of the asbestos-asphalt mixture was higher than any of the other filler-asphalt systems under study. Similarly, combinations of asphalt with hydrated lime showed higher viscosities (but lower softening points) than combinations of asphalt with kaolin clay.

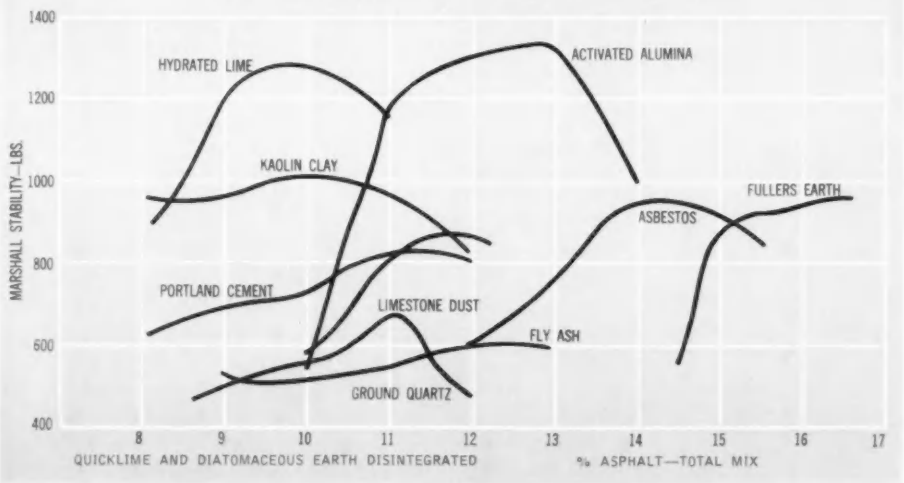
THE JUMPING-OFF PLACE

What did it all prove? Nothing. But all these wild cards in the deck convinced the investigators they had to narrow their search to find some common denominator, a jumping-off place. Somewhere, on the slippery face of the problem there had to be a toe-hold. They asked themselves: Maybe the secret lies in the surface areas of these fillers with their wide range of adsorptive capacities?

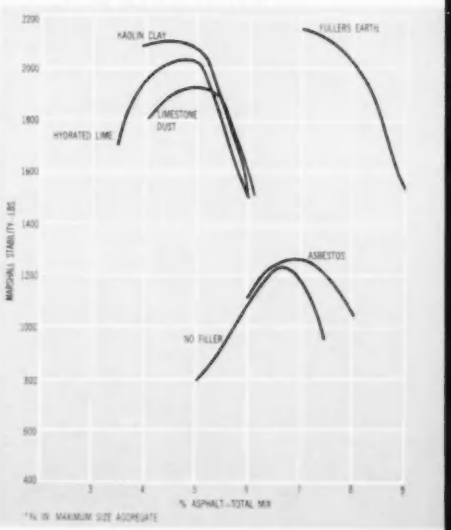
Explorations in this area turned up interesting, but not entirely conclusive, information. It was learned that the surface areas for the eight mineral powders under study varied widely. Activated alumina, for instance, retained about one hundred times more glycerol (in the glycerol sorptive test) than ground quartz sand, and those fillers which retained more glycerol also adsorbed more asphalt, as a general rule.

2. EFFECT OF FILLER TYPES ON STABILITY OF SHEET ASPHALT

Regular Mixing; Tested After 18 hrs. Immersion at 140 °F.



5. EFFECT OF FILLER TYPES ON DENSE-GRADED MIXTURES



But there were conspicuous mavericks in the statistical herd. For example, alumina retained the highest amount of glycerol, but showed only a moderate affinity for asphalt. And kaolin clay retained only about one-fifth as much glycerol as the activated alumina—but showed a far greater affinity for asphalt. Further, it was discovered that the glycerol retention method couldn't be used to test two of the fillers—lime and portland cement—because of a chemical reaction that produced erratic test data.

It was found that the glycerol retention of fillers correlated, to a degree, with the hygroscopic moisture content (rate of water vapor sorption) of the fillers. For example, a sheet asphalt type mix with fillers of high hygroscopicity tended to weaken rapidly when immersed in water. The investigators asked themselves: Should we test filler for hygroscopicity? Perhaps that must come.

PROBE CONTINUES

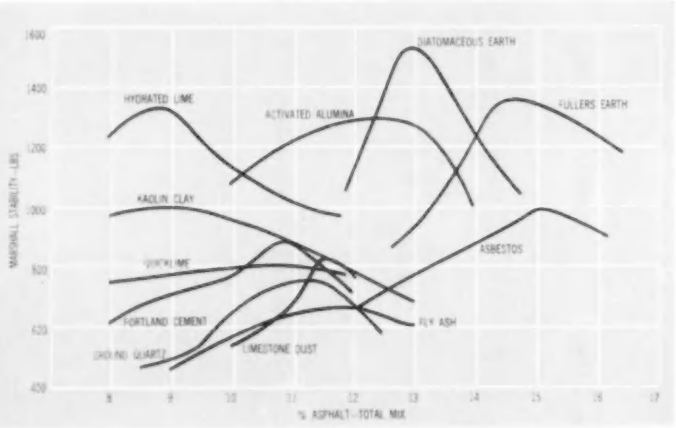
Meanwhile, the investigation proceeded like opening up an artichoke: as each leaf was peeled away it opened up new areas for speculation and additional research. In addition to testing normal mixtures, other tests were conducted with samples in which the mineral filler was pre-mixed with the asphalt cement. This produced some interesting data. It was found that, generally, the susceptibility of paving mixtures to water could be reduced by pre-mixing the filler and asphalt before blending with the aggregates. For example, a normal mixture of sheet asphalt with a diatomaceous earth disintegrated upon immersion. When pre-mixed with the asphalt cement, on the other hand, it produced the highest stability curve on the chart (see Charts 2 and 4). On the other hand, mixes with quicklime (highly reactive to water) disintegrated readily under both conditions.

Data derived from the glycerol sorption tests permitted an arbitrary grouping of fillers by types. Regarded as highly adsorptive are Fuller's earth, alumina, calcium oxide and kaolin clay. Somewhat less adsorptive are portland cement, asbestos fiber, hydrated lime and diatomaceous earth—with quartz sand, limestone dust and fly ash regarded as the least adsorptive of the fillers used in the investigations.

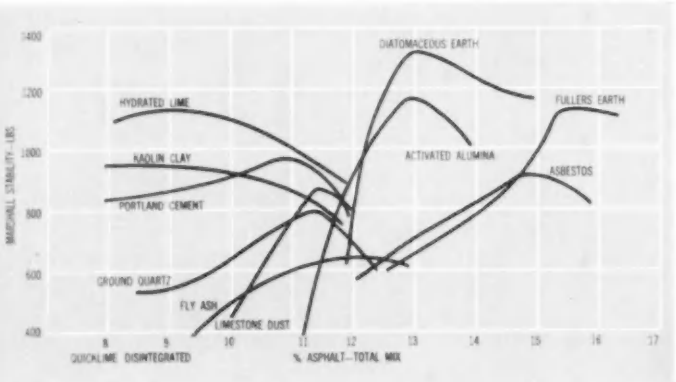
A general relationship between the surface areas of the fillers (as determined by the sorption test method) and the viscosity of the filler-asphalt mixture was established. Mineral fillers with the largest surface areas adsorbed the greatest amount of asphalt. Viscosities of the mixtures generally, but not consistently, increased with the increasing fineness of the filler. And increasing concentrations of filler resulted in increased viscosity and non-newtonian flow behavior of the mixture.

Speculation has zeroed in on two closely related aspects of the study: surface areas of the fillers and their capacity for adsorbing asphalt. Polar attraction probably enters into the picture at this point, but to what extent we don't know at this time. Spectrophotometric and gravimetric tests confirm this, but a more sophisticated method of measurement is needed.

3. EFFECT OF FILLER TYPES ON STABILITY OF SHEET ASPHALT
Pre-Mixed; Regular Testing



4. EFFECT OF FILLER TYPES ON STABILITY OF SHEET ASPHALT
Pre-Mixed; Tested After 18 hrs. Immersion at 140° F.



ASBESTOS GETS HIGH MARK

As this investigation probes deeper and deeper into a very complex subject, information gathered to date gives a high mark to asbestos fiber filler. It appears to meet most of the requirements of a sound, working filler with a minimum of the "bugs." Other fillers—kaolin clay and hydrated lime—showed some of the desirable characteristics under most conditions.

Field testing, of course, is the ultimate proof of the value of a filler material. Dense-graded mixtures containing asbestos filler are now being field tested in several locations. Similar field tests should be made with mixes containing kaolin clay and hydrated lime fillers. Another filler which performed less impressively in the laboratory, but well enough to be described as deserving of controlled field study, was limestone dust, a readily available filler material in common supply.

It's interesting to note that the Institute lab studies graded a plastic material—kaolin clay—rather high. Normally, plastic materials are not regarded as acceptable for this purpose and, in fact, specifications usually limit filler to non-plastic materials.

These are all guideposts along an uncharted way. The laboratory team at The Asphalt Institute, using these signposts to take fresh bearings, are moving on into a subject that seems to grow steadily more complex and, consequently, more challenging.

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